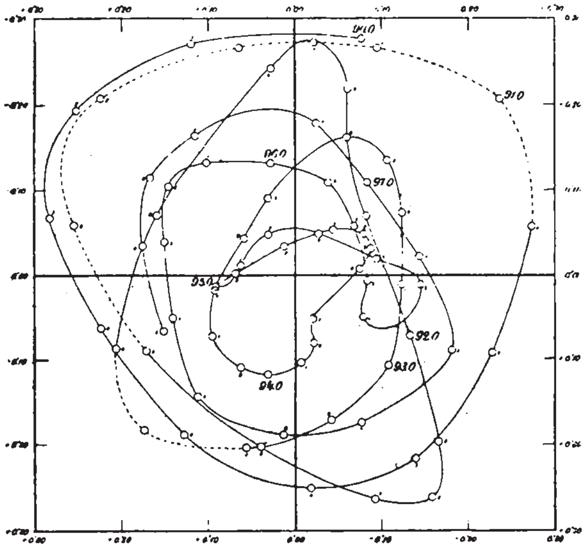
THE MOVEMENT OF THE EARTH'S POLAR AXIS 1890·0-1897·5.—To the *Astr. Nachr.* (No. 3489) Prof. Albrecht contributes a short abstract of an investigation which he has just completed on the path of the earth's polar axis. In a previous number of the same journal (No. 3333) he gave the result of a similar piece of work for the period 1890·0-1895·2. The mass of material that has since accumulated has led Prof. Albrecht to reinvestigate the motion from the beginning, or, in other words, to trace the movement of the pole for the whole period 1890·0-1897·5. An examination of the resulting curve shows that from the year 1890 to 1895 a decrease in the amplitude took place, the curve towards the time of the latter year being not very far distant from the position of the mean pole. From 1895 the amplitude began to increase, but without reaching the value of that attained in the year 1890. The curve during the interval 1897·0-97·8 approached the mean pole by quite a tenth of a second more than it did during the period 1890·0-90·5. Prof. Albrecht consequently points out that since the curve does not repeat itself after a period of seven years, the orbit of the pole's movement cannot be represented by a term of twelve and of fourteen months period.



Movement of the north pole of the earth's axis.

Comparing the observed and calculated values of $\phi - \phi_0$, he is led to infer that a part of the series of observations is more or less affected by systematic errors, the great portion being due to refraction disturbances. To remedy this in future it is pointed out that greater care must be taken to ensure equality of refraction towards the north and south by having large openings (shutters) in the observing room, and by placing the instrument central as regards the shutters. Further, mention is made of the locality of the observatory, and such positions should be chosen where the land and vegetation conditions towards the north and south do not offer great contrasts.

COMET PERRINE (MARCH 19).—The following ephemeris for this comet is continued from *Astr. Nach.*, 3488.

Berlin Midnight.

1898.	R.A. h. m. s.	Decl. ° ′	Br.
May 12	1 36 25	+54 16·3	0·38
13	41 42	54 29·1	
14	46 56	54 41·1	
15	52 8	54 52·2	
16	1 57 18	55 2·5	0·33
17	2 2 25	55 12·1	
18	7 30	55 21·0	
19	2 12 32	+55 29·1	

During the present week the comet approaches the vicinity of the well-known great cluster in Perseus.

THE NORTHERN "DURCHMUSTERUNG."—A committee, consisting of Profs. E. C. Pickering, J. G. Hagen and M. B. Snyder, informs us (*Astrophysical Journal*, No. 4, April 1898) that a new edition of the *Durchmusterung* is being prepared by the Bonn Observatory, and will shortly be published, provided that subscriptions for a hundred copies at seventy marks each are promised. The fact that the original edition of this work is exhausted, and that the price asked was exceptionally low, should have induced many libraries and institutions to have taken this opportunity and become possessors of the work. It is stated that after May 1 of this year the price will be raised to one hundred and twenty marks, so that, if this date be adhered to, the opportunity for obtaining copies at the cheaper price has been missed.

THE ASTRONOMICAL SOCIETY OF WALES.—In this column we have several times referred to the excellent work the Astronomical Society of Wales is doing in promoting the study of astronomy and the allied sciences. The Society has just published in a new form and under somewhat new conditions the first issue of their quarterly journal, the *Cambrian Natural Observer*, which it is hoped will appear regularly. In the introduction we are told, "for some reason or other science does not seem to flourish in Wales; yet, the opportunities for the observation of natural phenomena—using these words in their broadest sense—are neither few nor unimportant." May the influence of the Society be so effective that such a statement as the above will in the next few years cease to be accurate.

SEA-BEACHES AND SANDBANKS.[1]

THIS paper is the sequel to one on "The Formation of Sand-dunes," in the *Geographical Journal*, March 1897. It embodies a research upon the processes which distribute the detritus which enters the sea at its margin, and upon the behaviour of the material distributed.

Fine mud settles through water with such extreme slowness, that wherever the bottom is disturbed by waves (say, to the edge of the continental shelf) it cannot anchor itself upon the bottom even during the slack water of the tides, so that the action of gravity is cheated. This leads to the conclusion that the transit of mud down the slope from the shore is not due to the action of gravity, but that the principal factor determining the well-known direction of mud-transport is the diminution of intensity of bottom agitation from the shallows to the depths.

The usual condition of sea-water is one of oscillation which is not quite symmetrical in amount (*i.e.* there is often a prevailing drift in one direction), and which is scarcely ever symmetrical in intensity, a short quick motion one way being balanced, as far as the movement of the water itself is concerned, by a long slow motion in the reverse direction.

The author shows how suitable oscillation on a seaward slope will set shingle travelling shoreward, and sand simultaneously travelling seaward. The condition of the transport of shingle (great intensity of motion) keeps most of it close against the shore, often in a bank or beach; while the inability of mud to settle except where the water is quiet causes it, as we have seen, to accumulate in mud flats beyond the limits of wave-action. The accumulations of sand are of greater variety, for, although the mean term in size, it possesses a greater independence of motion, or persistence, or effective inertia, than either of the extreme terms. Mud (by which is intended throughout such characteristic marine mud as the well-known "blue mud") obeys each slightest swirl of the water; it follows almost exactly the stream-lines; and it is only in the slow settlement of the mud in still water that muddy water behaves otherwise than as an emulsion. Shingle, again, is not raised to any great height from the bottom, and sinks so swiftly that it does not take a long free flight in water. Hence, when it is moving it follows almost precisely the direction of the momentary movement of the water. Sand, on the other hand, is frequently churned up to a considerable height from the bottom, and often has a long free path; but when the stream-lines of the water are suddenly deflected, whether vertically or horizontally, inertia carries the sand on, the stream-lines of the sand being deflected less than those of the water. Similarly, when the current slackens the sand flings itself forwards, as is so noticeable in the rippling of sand by waves. It is owing to its persistent motion that sea-sand accumulates in vast banks where it is flung by the sudden bending or checking of currents (*e.g.* at tidal nodes), or where it is dropped during tumultuous mixing of waters.

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[1] By Vaughan Cornish, M.Sc. (Vict. Univ.). (Abstract of a paper read before the Royal Geographical Society on March 16, published in the *Geographical Journal*.)

The wash of the waves, owing to percolation, piles up the pebbles thrown forward by the breaker, forming a bank, or ridge, or Full, and this is the action proper to the sea on a shore of shingle.

The piling up of the ridge goes on, its height and steepness increasing, until the wash can reach no higher, and the steepness of the ridge at each point is such that the assistance which gravity gives to the down-flowing surface stream counterbalances the loss of transporting power due to percolation at that level. This is the equilibrium profile or regimen of the Full. Now, the greater the volume of water flung forward by the breaker, the greater is the depth of the back-flowing surface stream, and thus for the same size of beach material the carrying power of the back-wash is more nearly equal to that of the on-wash. Consequently, in a given locality, the regimen slope of beach proper to a rough sea is not so steep as that for a quiet sea.

It is evident that the greatest amount of transport can occur when the sea acts upon the greatest quantity of shingle—that is to say, when the sea is at its highest level. The transporting power increases in a more rapid ratio than the rise of level, owing to the circumstance that most of the shingle is accumulated on the landward side of the beach, where its thickness is greatest. It follows that a wind blowing in the direction of the flood tide will have an advantage in shingle-transport over the wind which blows with the ebb; for the former, by opposing the turn of the tide, tends to increase the duration of tidal high water, and to diminish the duration of tidal low water. Thus, although the forces of currents may be equal and opposite in the two cases, the opportunities of action on shingle are greater when the wind blows with the flood tide. Again, the waves break most violently on the steep beach near high-tide mark, which further increases the effect of prolonged high water in promoting transport. The along-shore wind which is accompanied by a low barometer has a corresponding advantage of opportunity over the along-shore wind which is accompanied by a high barometer, and the wind along-shore which blows from the greater expanse of water over the wind which blows from the less.

No stony particle of less than a certain critical size can remain permanently on a beach, but is ultimately swept out to sea. This critical size is greater on a coarse-grained than on a fine-grained beach, for the regimen slope of the former is steeper, and gravity therefore gives greater assistance to the back-wash. It is well known that every particle upon the surface of a beach suffers attrition, whence the conclusion has been too hastily drawn that the grain of an isolated beach naturally becomes finer as the distance increases from the extremity where the beach is fed with detritus. Now, it is to be noted that whereas the attrition of the particles tends to lower the average size of the shingle, and hence to make the grain of the beach finer, the removal of particles of less than the critical size raises the average dimension of the shingle. Hence we may deduce the following laws of grading of beach shingle applicable to a beach fed entirely at one extremity, whence the material travels along the beach:—

Law 1.—If the material be of uniform size, the grain of the beach becomes finer as we recede from the extremity.

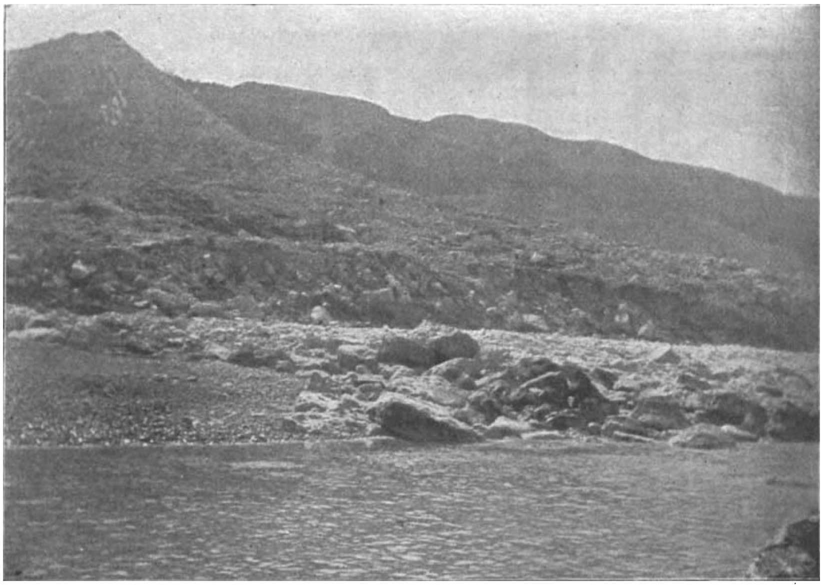
Law 2.—If the material be mostly fine stuff, with a small admixture of coarse stuff, then (unless the coarse stuff be very friable, and the fine stuff very durable) the grain of the beach will become coarser as we recede from the extremity, for the average size is more affected by the removal of a large number of fine grains than by the attrition of a small number of coarse grains. This increase in coarseness will continue until the beach material is brought to a uniform size, when the grading proceeds as in 1.

Law 3.—If the material be mostly coarse stuff, with a small admixture of fine stuff, then, as we recede from the extremity, the grain of the beach will become finer, for the attrition of a great number of large particles has a greater effect upon the average size of the material than the removal of a small number of fine particles.

By combining 2 and 3 we can deduce corollaries applicable to the case of a beach fed from both extremities.

Law 4.—The grain of the beach is (*ceteris paribus*) coarser where the beach is exposed to the heaviest breakers. This law follows from what has been said on the action of the back-wash, and on a "critical size" of beach material.

Law 5.—The grain of the beach is (*ceteris paribus*) coarser near the "weather" end of a promontory. Thus, if west be the weather side, and the end of a long beach is protected from the east by a headland at the eastern extremity, then both large and small pebbles will travel eastward along the beach in a westerly wind, but only the small ones are carried back from the promontory during an east wind, so that the proportion of large pebbles to small is increased as we near the promontory from the west. This is, in fact, similar to the case of the sorting of sand from shingle by unsymmetrical oscillation.



[*From a photograph by the author.*

FIG. 1.—East end of Chesil Beach.

The author considers that the chief factors which determine the observed grading of the Chesil Beach are as follows:—

(1) The beach is fed at both ends (Bridport and Chesilton).

(2) The material fed in at the west end is mostly fine, owing chiefly to the natural groynes at Golden Cap and Thorncombe.

(3) The material fed in at the east end is mostly coarse, owing to the nature of the local rock and the mode in which it is supplied to the foreshore.

(4) The main drift of water is easterly, but

(5) Of the fine shingle carried eastward from Bridport, much is brought back by waves from the east; whereas

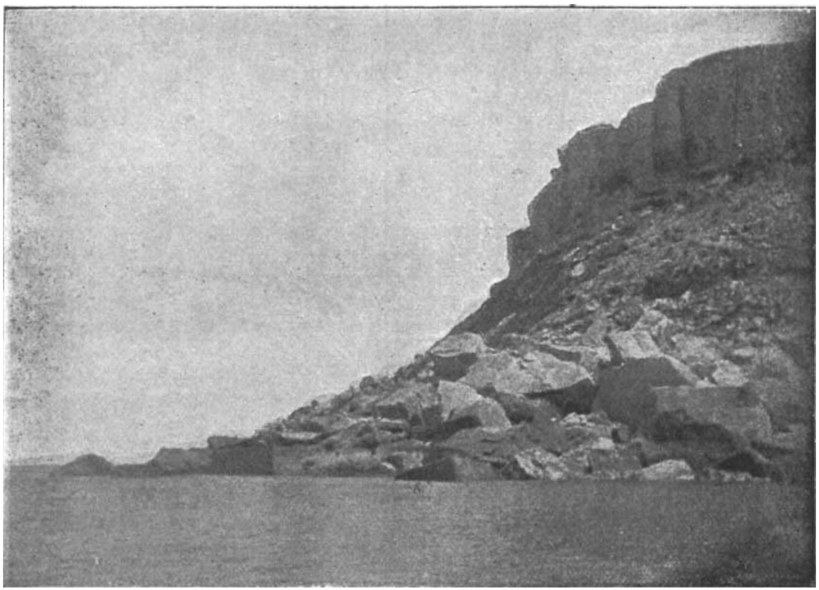
(6) The strong outset at Chesilton removes such fine stuff as may be there supplied from Portland.

(7) The largest waves converge on Chesilton from both sides.

The formation of a beach-ridge, or Full of sand, is well seen when the sand is being brought in during off-shore winds. Sand being readily raised by upward-swirling water (which is equivalent to suction dredging), the building up of a Full of sand in front of the breaker is accompanied by the excavation of a trough, or Low, at the back of the breaker. This is roughly similar to the simultaneous excavation and elevation which produces the ridge and furrow so well known as "ripple-mark." Fine dust or mud settles too slowly, coarse shingle too quickly, to lend themselves readily to this mode of distribution by waves. A Low is dredged out in sand when the breaker-line remains stationary for a time, as *e.g.* during tidal high water. During the ebb of spring tides, a lagoon is often left between the beach and a second stretch of sand. This lagoon marks the strip where the breakers act during the period of neap tides. At low water of spring tides, the belt of sand beyond the Low is a sort of beach, the seaward face of which is where the wash of the waves acts. Beyond it, during the continuance of the spring tides the breakers commence the formation of a second Low. When the tide is up and the sea is rough, there is an outer line of breakers on the bank, which is locally called the Ball.

The connection between tidal nodes and the accumulation of sandbanks is dealt with, and the analogies with sand dunes are pointed out.

With regard to the sandbanks which accumulate on the more sheltered side of headlands, a good example of which is the Shambles shoal, eastward of Portland Bill, it is pointed out that the materials (broken shells, &c.) which form the Shambles sandbank are not deposited in still water. The sand deposits from the mixing waters of meeting streams, an effect that is not surprising when we consider that the mixing of waters is achieved by vortices.



[From a photograph by the author.

FIG. 2.—Blacknor Point, Portland.

The checking and deflection of the streams is probably not nearly the whole of the mechanism by which the deposition of sand is brought about where a river meets the sea. A great part of this effect is probably due to the motions which attend the mixing of waters, a process which appears to be almost as potent a factor in the formation of sandbanks as is the mixing of airs in the production of clouds.

THE BACTERIAL CHARACTER OF CALF-LYMPH.

QUITE a flutter of excitement was produced in the ranks of the anti-vaccinators by the public announcement, made rather more than a couple of years ago, that lymph used for vaccination purposes frequently contained an immense number of bacteria, sometimes as many as two and one-half millions in a single cubic centimetre, and that amongst this vast microbial population forms were repeatedly present which, on inoculation, proved fatal to animals. A certain measure of authority was given to this communication, inasmuch as its author, Dr. Landmann, claimed to have carried out a very large number of experiments in support of his assertion; and his results were, moreover, brought before the well-known German Association of Naturalists and Physicians at one of its yearly meetings. Coupled, as Dr. Landmann's conclusions were, with the recommendation that only lymph should be used for inoculation purposes which had been officially declared germ-free—or, at any rate, devoid of pathogenic bacteria—his announcement gave such an impetus to the anti-vaccination crusade, and occasioned so much public discussion, that the Prussian Ministry felt it their duty to appoint a Commission to inquire into the character of calf-lymph. Meanwhile independent experimental inquiries were also started by various investigators, and amongst these Dr. Neidhart was able to show that Landmann's assertion that the red inflammatory margin of the pustules so frequently noticeable was directly due to the action of the bacteria present in the vaccine was not correct, inasmuch as such symptoms were produced when lymph quite free from bacteria was employed, whilst they were often absent in cases where the lymph was proved to be teeming with bacteria. The hysterical excitement caused by the circulation of Landmann's sensational statements was, however, considerably abated by the publication of the masterly report drawn up by Frosch upon the very large number of most valuable experiments undertaken in a purely scientific, uncontroversial spirit by the Prussian Committee of inquiry above referred to.

This document completely refuted Landmann's statements, and showed that the alarming conclusions arrived at by him had no real foundation in fact. Frosch further indicates, as the result of careful experiment, the best methods and most suitable precautions to be adopted in the inoculation of calves and the collection and application of the lymph, pointing out in the latter connection that local irritation from vaccination may be greatly moderated by diluting the lymph with glycerine.

These reassuring results were again independently confirmed by Kirchner, of Hanover, who, in extensive examinations of calf-lymph, found on no single occasion any pathogenic bacteria.

In the current number of the *Zeitschrift für Hygiene* the question has been again brought to the fore by the publication of elaborate experimental researches on the bacterial character of calf-lymph by Dr. Dreyer, of the Hygienic Institute of the University of Giessen.

Careful quantitative determinations of the bacterial contents of calf-lymph showed that the initial number of microbes present may vary considerably, and that in the majority of cases it is very large indeed—on one occasion reaching as many as 17½ millions in one cubic centimetre. Within twenty-four hours, however, a great diminution takes place; but this decrease does not continue at the same rapid rate. Thus, to cite one instance: a sample contained on the first day of its collection over 2½ millions of bacteria per c.c.; after five days, 112,750; after eighteen days there were still, however, 111,765 present. Some forms persist over very long periods of time; Dreyer observed bacteria after a lapse of five months, whilst Kirchner found 550 in a cubic centimetre sample over a year old.

To determine the pathogenic character of lymph-bacteria, Dreyer inoculated, subcutaneously and intraperitoneally, both mice and guinea-pigs. Out of thirty-five mice thus treated only two succumbed, one to subcutaneous and the other to intraperitoneal inoculation; in none of the other animals was any reaction perceptible. As regards the guinea-pigs, in no single instance did any result follow the intraperitoneal inoculations, whilst in nearly every subcutaneous inoculation a small and insignificant abscess was observed to form at the point of inoculation.

Not satisfied with these experiments, Dr. Dreyer experi-